JOURNAL

OF

SOUTH AFRICAN BOTANY

VOL. XXVII.

Published: 27th October, 1961

SOME AQUATIC HYPHOMYCETES IN SOUTH AFRICA

By S. K. Greathead

(*Department of Botany, Rhodes University, Grahamstown*)

(With Plates XXVII—XXIX)

ABSTRACT

Eighteen species of aquatic hyphomycetes growing on decaying leaves in running streams are described. Sixteen of these can be assigned to known species and the other two are new species of *Articulospora* and *Anguillospora* and are described in this paper. Notes on spore development in ten species, general notes on ecology and a key to these fungi are given.

INTRODUCTION

Many species of aquatic hyphomycetes common to Europe (Ingold 1942 and later papers), California (Ranzoni 1953) and Jamaica (Hudson and Ingold 1960) have been recorded for the first time from South Africa. Some of these have also been recorded from Uganda and Rhodesia (Ingold 1958), Nigeria (Ingold 1956 and 1959) and Ghana (Dixon 1959).

Table I records the fungi found in the Eastern Cape Province of South Africa, their distribution within the localities and the nature of the material on which they were growing. Unless otherwise indicated, the substrate was a decaying leaf.

TABLE I.	GRAHAMSTOWN DISTRICT.														near ALICE		HOGSBACK																PORT ELIZABETH	
	Fern Kloof	Featherstone Kloof	Belmont Valley		Paradise Kloof					Howiesons Poort					Tyumie River		Plantation	Plantation					Natural Forest										Baakens River	
	Unidentified leaf	Quercus robur	Populus nigra	Quercus robur	Ocotea bullata	Cassine sp.	Canthium bispinosum	Celtis africana	Rapanea melanophloeos	Rhus legati	Unidentified leaf	Rapanea melanophloeos	Burchellia bubalina	Ficus capensis	Combretum caffrum	Salix babylonica	Populus serotina	Quercus robur	Eucalyptus globulus	Acacia sp. decaying fruit	Buddleja salvifolia	Rubus sp.	Plectranthus ecklonii	Celtis africana	Xymalos monospora	Rhus legati	Grewia occidentalis	Maytenus cymosus	Calodendrum capensis	Fagara davyi	Podocarpus latifolius	Polystichum sp.	Salix babylonica	Populus sp.
Lunulospora curvula		X	X		X	X		X		X				X	X		O	O	X			X		X	X			X					O	
Flagellospora penicillioides ..			Z																									X					O	
F. curvula															X							X			X	X				X	X			
Anguillospora filiformis							O	O	X	X																				X				
A. longissima			X																			X						X						X
Tricladium splendens																	X	X				X						X						
T. gracile			X														X	X	X		X	X		X		X	X	X			X			
Heliscus longibrachiatus																		X	X	X								X						
Clavariopsis aquatica			X	X													X	X		X		X												O
Tetracladium setigerum																	X											X						
T. marchalianum			X	X											X			X					X										ZX	
Articulospora inflata											X						X																	
A. tetracladia	X	X						X	X	X	X						X	X						X		X		X						
Articulospora grandis								X	X			X																						
Alatospora acuminata			O				X	X		X		X	X	X	X		X	X	X	X	X	X					X	X	X		X	X		
Triscelophorus monosporus ..			X					O		X		X	X		X					X														
Lemonniera aquatica																	X	X						X										
L. brachycladia																					X					X				X				

X—spore attached to conidiophore of fungus growing on leaf, etc.
O —free floating spore.
Z—culture of fungus on malt agar from free floating spores

METHODS

After collection the decaying leaves were placed in shallow dishes of water. Spore production ceased after about two days, but could be prolonged for about a week, if the leaves were placed in jars of water which was constantly aerated.

Spore development of fungi growing on decaying plant material has been followed in hanging-drop cultures. At first ordinary closed rings were used but in several cases under these conditions certain irregularities in the shape of the spores developed were observed. It was decided that this might be due to the development of anaerobic conditions and so rings with an inlet and outlet tube were used and air was passed through the ring for a few minutes approximately once an hour. Under these conditions spore development appeared to be quite normal. The drawings of developing spores and the other text figures were all made with the aid of a camera lucida.

Cultures of some of the fungi have been made by spraying spores onto the surface of 2% malt agar. When these spores had germinated, they were transferred to fresh plates of the same medium. It was found that the results were more successful, when stream water rather than distilled water was used in making the medium.

DESCRIPTION OF SPECIES AND SOURCES OF MATERIAL

The four main areas in which these fungi have been collected are the Grahamstown district, Port Elizabeth, the Hogsback in the Amatola Mountain Range and from near Alice. The sites within these main localities are as follows:—

1. **Grahamstown district:**

(*a*) A streamlet in an islet of natural forest in Fern Kloof on the south-facing slope of the hills south of Grahamstown.

(*b*) A stream, the headwaters of the Kowie River, in Featherstone Kloof below Fern Kloof. The stream at this site is overhung by oak trees.

(*c*) Blaaukrantz River, 5 miles from Grahamstown on the Belmont Valley Road. The stream is overhung by *Populus nigra* and *Quercus robur*. Decaying leaves of these trees are held back by rocks in the shallows, where the water is running swiftly.

(*d*) A small stream in Paradise Kloof, an islet of natural forest on a south-facing slope 6 miles from Grahamstown on the Highlands road.

(*e*) A tributary of the Palmiet River, in Howiesons Poort on the Port Elizabeth Road. The stream is overhung by indigenous trees and shrubs and by the exotic shrub *Acacia longifolia.*

2. The **Baakens River,** the Nature Reserve, Port Elizabeth:

(*a*) In a *Populus sp.* plantation. The fallen leaves are caught on sticks lying across the stream.

(*b*) Rocky shallows beneath trees of *Salix babylonica* below a weir.

3. The **Hogsback,** Amatola Range:

(*a*) Seven streams in natural forest on south-facing slopes, four in the lower forest and three in the upper forest.

(*b*) A streamlet running through a plantation of *Quercus robur.*

(*c*) A streamlet running through a plantation of *Populus serotina* (? *P. nigra x deltoides*). The fallen leaves lie on the surface of the mud with a trickle of water running over them.

(*d*) Two streams in mixed plantations of exotic trees. The fallen leaves are caught on sticks lying across the stream bed.

4. The **Tyumie River** 8 miles from Alice on the road to the Hogsback. Decaying leaves of *Combretum caffrum* and *Salix babylonica* are held up behind stones in the shallows, where the water is running rapidly.

Of the eighteen species found, all except two could be assigned to described species. The other two fungi are new species of *Articulospora* and *Anguillospora* and are described in this paper. All the descriptions of the known species, unless otherwise stated, are taken from Professor Ingold's publications.

Lunulospora curvula Ingold. (Plate XXVII, A.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore simple or sparingly branched, 50—200 μ long, 2—2·5 μ broad. Conidium (aleuriospore) produced terminally on a short stalk cell 3—5 μ long 1·5 μ broad. By repeated budding from the end of the conidiophore a number of spores may be produced in succession (but not basipetally), each seated on a stalk cell. Aleuriospore unicellular, crescent-shaped or sigmoid, 70—90 μ long, 4—5 μ broad in its middle region, tapering to 1·5 μ at its ends, with a row of conspicuous vacuoles. Attached at a point along its convex surface to the stalk cell. Liberated spore with an inconspicuous hilum where it was originally attached to the stalk cell.

"On submerged decaying leaves of *Alnus glutinosa* and *Salix sp.* from a stream in Leicestershire, England." (Ingold 1942).

Other records of *Lunulospora curvula* are from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960) and from Rhodesia (Ingold 1958). The fungus was found on submerged decaying leaves of *Celtis africana*, *Xymalos monospora*, *Maytenus cymosus*, *Eucalyptus globulus*, *Rubus sp.* and on a decaying fruit of *Acacia sp.* from the Hogsback, on decaying leaves of *Populus nigra* from the Belmont Valley, of *Quercus robur* from Featherstone Kloof, of *Rhus legati* from Howiesons Poort and of *Ocotea bullata*, *Cassine sp.* and *Celtis africana* from Paradise Kloof. Conidiophores were abundant in collections made in April and May but were much less common in June, July and August.

It was observed that there is a great variation in the length of conidiophore projecting from the leaf tissue. The length was 13 μ in the fungus growing on Oak leaves from Featherstone Kloof, whereas it was 50—80 μ in the fungus on Poplar leaves from the Belmont Valley.

Spore development was followed in hanging-drop cultures of the fungus growing on decaying leaves of *Populus nigra* and *Xymalos davyi* (Fig. 1).

While the development of the first spore is proceeding, the primordium of the second spore arises as a protuberance on the end of the conidiophore to one side of the first spore. Ingold (1942) observed that the protuberance was first cut off from the conidiophore by a septum and that a second septum was formed cutting off a small basal cell which is the stalk cell. These two septa were not, however, always apparent (see second septum Fig. 1, a, both septa Fig. 1, t). The spore primordium enlarges and elongates and after about three and a half hours a second growing point develops near its base (Fig. 1, h, i, p, q). Both growing points continue to grow until a crescent-shaped or sigmoid spore is developed (Fig. 1, g, h, t). The spore takes about six hours to develop at laboratory temperature as compared with ten hours observed by Ingold (1942). The spore is liberated by the breakdown of the stalk cell. Whereas Ingold (1942) observed the remains of the stalk cell were never left attached to the spore or the conidiophore, they have often been found attached to the conidiophore but not the spore (Fig. 1, t).

Flagellospora curvula Ingold. (Plate XXVII, B.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore usually branched forming a group of two to ten phialides. Each phialide clavate, 10—20 μ long, 2·5 μ broad, producing conidia (phialospores) in basipetal succession. Conidium curved or sigmoid, hyaline unicellular, 100—150 μ long, 2 μ broad in the middle region tapering to 1·5 μ towards its ends.

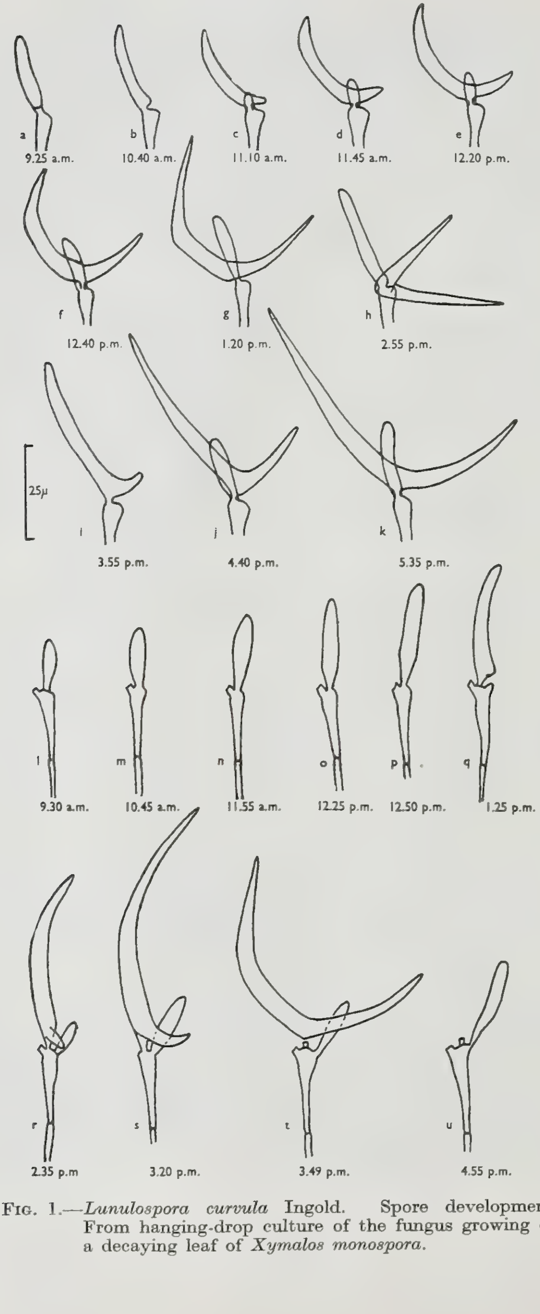


FIG. 1.—*Lunulospora curvula* Ingold. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Xymalos monospora*.

"On submerged decaying leaves of *Alnus glutinosa* and *Salix sp.* from a stream in Leicestershire, England". (Ingold 1942).

Other records of *Flagellospora curvula* are from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960), from Switzerland (Ingold 1949), from Ghana (Dixon 1959) and Rhodesia (Ingold 1958). This fungus has been found growing on submerged decaying leaves of *Xymalos monospora*, *Rhus legati*, *Fagara davyi* and *Podocarpus latifolius* and of *Rubus sp.* from the Hogsback and on skeletonised leaves of *Combretum caffrum* from the Tyumie River. This fungus was common in August but not from April to July.

Flagellospora penicillioides Ingold. (Plate XXVII, C.)

"Submerged aquatic fungus with branched, septate mycelium. Mycelium on malt agar hyaline at first, later bright brown with moniliform chains of inflated, oil-containing brown cells (chlamydospores) 15—35 μ long, 8—16 μ broad, occurring in the older parts of the aerial mycelium. Aquatic conidiophores hyaline, branched as in *Penicillium*: unbranched stalk part 150—300 μ long, 2·5 μ broad: apical phialides 8—40, 15—20 μ long, 2·5 μ broad. Conidia (phialospores) hyaline, 45—55 μ long, 2·5 μ broad, in the middle but tapering to 1·5 μ at the ends, unicellular or uniseptate, curved or more usually slightly sigmoid, produced in basipetal succession from the phialides. Aerial conidiophores produced sparingly on malt agar, resemble the aquatic conidiophores but produce heads of slimy conidia.

"On submerged decaying leaf from a stream near Reading, England". (Ingold 1944).

Flagellospora penicillioides has also been recorded from California (Ranzoni 1953) and from Jamaica (Hudson and Ingold 1960). This fungus was found in August growing on a submerged decaying leaf of *Maytenus cymosus* from the Hogsback and has been isolated in culture on malt agar from spores from the Belmont Valley. The cultural characteristics of this fungus agree with the description quoted above. However, spore production from strips of the culture placed in sterile water took three to four days to commence, whereas Ingold (1944) found that spores were produced within two days.

Anguillospora longissima (Sacc. & Syd.) Ingold. (Plate XXVII, D.)

"Submerged aquatic fungus with branched septate mycelium which is hyaline when young, becoming greenish grey when old. Conidiophore usually simple, 50—150 μ long, 2—4 μ broad. Conidium (aleuriospore) terminal, 200—350 μ long, 5—6 μ broad in middle region tapering to 3—4 μ broad at ends, 6—10 septate, curved or sigmoid, separating when mature by the breakdown of a 'small separating cell' at the end of the conidiophore. On submerged decaying alder and willow leaves, England." (Ingold 1942.)

Other records of *Anguillospora longissima* are from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960) and from Rhodesia (Ingold 1958). This fungus has been found growing on submerged leaf skeletons of *Maytenus cymosus* and of *Rubus sp.* from the Hogsback and of *Populus nigra* from the Belmont Valley and from Port Elizabeth. This fungus was absent from collections made in April but was present as a few isolated spores in May and increased in abundance from June to August.

Anguillospora filiformis n. sp. (Plate XXVII, E) (Fig. 2).

Submerged aquatic fungus, mycelium embedded in tissue of decaying leaf. Conidiophore simple, 3 μ broad, slightly inflated towards the apex Conidia (aleuriospores) terminal, elongate, septate, hyaline, 200—250 μ long, 3·8 μ broad. Sides of spore almost parallel, converging towards the apex. Small lateral outgrowth on side of spore near base, becoming more or less parallel with sides of spore.

Hab. On submerged decaying leaves from streams in the Eastern Cape Province of South Africa.

Anguillospora filiformis sp. nov.

Fungus aquaticus, submersus, mycelio in folio putrescenti inserto. Conidiophora simplicia 3 μ lata, subinde apice moderate inflata. Conidia (aleuriosporae) acrogena, elongata, septata, hyalina, 200—250 μ longa, 3·8 μ lata. Latera spori paene parallela, ad apicum alternata. Parvus processus lateralis prope ad basim spori situs, lateribus spori plerumque parallelus.

Hab. In folius putrescentibus, in fluminibus in orientale parte Capicae Provinciae Africae Australis submersis.

This species was found growing submerged on a decaying leaf of *Fagara davyi* from the Hogsback, on decaying leaves of *Rapanea melanophloeos* from Paradise Kloof and on an unidentified leaf from Howiesons Poort. Spores are common in the streams of Paradise Kloof and Howiesons Poort from June to August. The conidium of this fungus differs from that of *Anguillospora longissima*, *A. pseudolongissima* Ranzoni, and *A. gigantea* Ranzoni in that it is only 3·8 μ broad, whereas the conidia of the other three species are 5—6 μ, 4·6—6 μ and 5—6 μ broad respectively, it further differs from the other three in the presence of a lateral process at the base, an appendage which they lack. The sides of the conidium of this fungus are parallel for most of their length but in *A.*

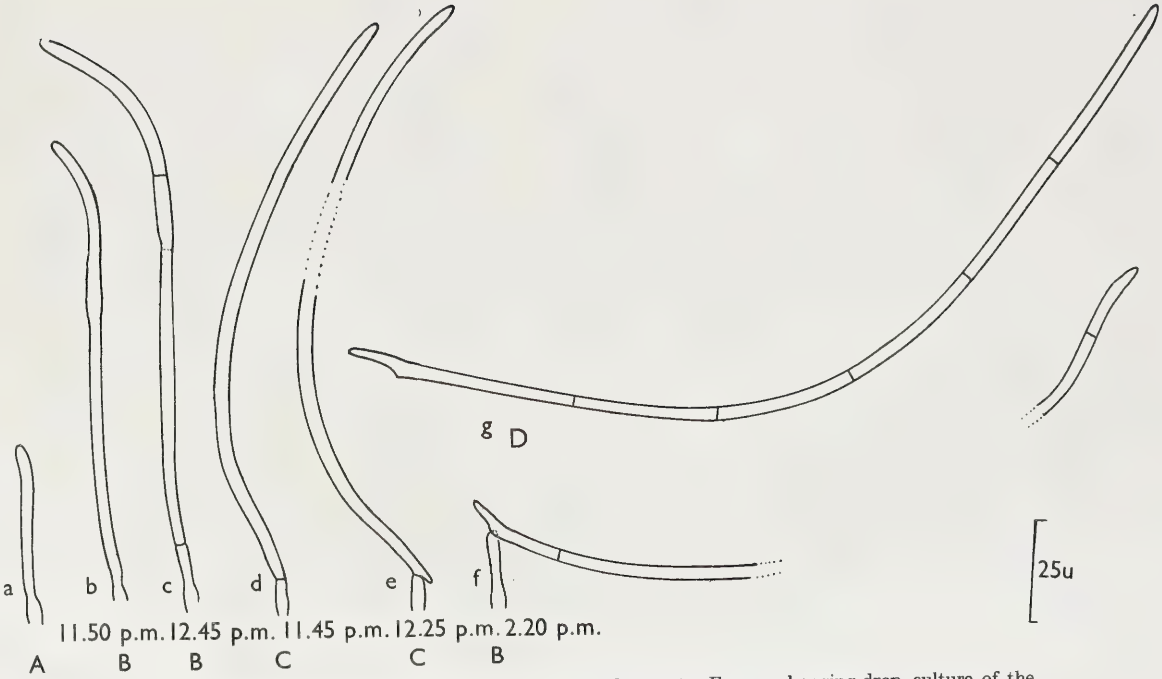


Fig. 2.—*Anguillospora filiformis* sp. nov. Spore development. From a hanging-drop culture of the fungus growing on a decaying leaf of *Rapanea melanophloeos*. Conidiophores with conidia (A, B and C) arranged in a developmental series. D. A mature spore after liberation.

flagellifera (Ingold) the conidium consists of two unlike portions, a truncate basal portion 10—14 μ broad and an upper whip-like portion.

Observations on spore development in *Anguillospora filiformis* have been made from hanging drop cultures of the fungus growing on leaf skeletons of *Rapanea melanophloeos.* A complete series of drawings of spore development for one spore has not yet been made but (Fig. 2) drawings of three spores (A, B and C) at various stages in development have been arranged in a developmental series. The spore primordium (Fig. 2, a) which is somewhat narrower than the inflated portion of the conidiophore elongates and becomes slightly broader in the upper half (Fig. 2, b). However, as the spore continues to elongate the sides become more or less parallel converging towards the apex (Fig. 2, d). A small knob-like process appears on the side of the spore immediately above the septum which has formed between the developing spore and the conidiophore (Fig. 2, c). This process elongates to form a short peg-like process which is about half as broad as the spore and which is orientated with its long axis almost parallel with the sides of the spore (Fig. 2, g). During its development the spore becomes septate. Liberation of the spore seems to be by the disintegration of the middle lamella between it and the conidiophore. It would appear that in reaching its full size and ultimate angle the process may assist in "pushing" the spore off the conidiophore. The spores germinate readily on 2 per cent malt agar.

Tricladium splendens Ingold. (Plate XXVII, F.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore usually simple. Conidium (aleuriospore) terminal, hyaline, consisting of a main axis, fusiform, 3—6 septate, 60—20 μ long, 6—7 μ broad at widest part, tapering to 2—3 μ at their apices, with a narrow isthmus, 2 μ wide, where each branch joins the main axis of the spore.

"The two branches originate from the main axis of the spore at levels 10—20 μ apart.

"On submerged decaying leaves of *Alnus glutinosa* from a stream in Leicestershire, England." (Ingold 1942.)

Tricladium splendens has also been recorded from California (Ranzoni 1953) and from Switzerland (Ingold 1949). This fungus has been found growing on submerged decaying leaves of *Populus serotina* and *Quercus robur*, *Maytenus cymosus* and of *Rubus sp.* from the Hogsback, where it was common in July and August, but was not found from April to June.

Spore development has been followed in a hanging-drop culture of this fungus growing on a decaying leaf of *Populus serotina* (Fig. 3).

The spore primordium develops as a club-shaped swelling at the end of a thin straight conidiophore from which it is cut off by a cross wall

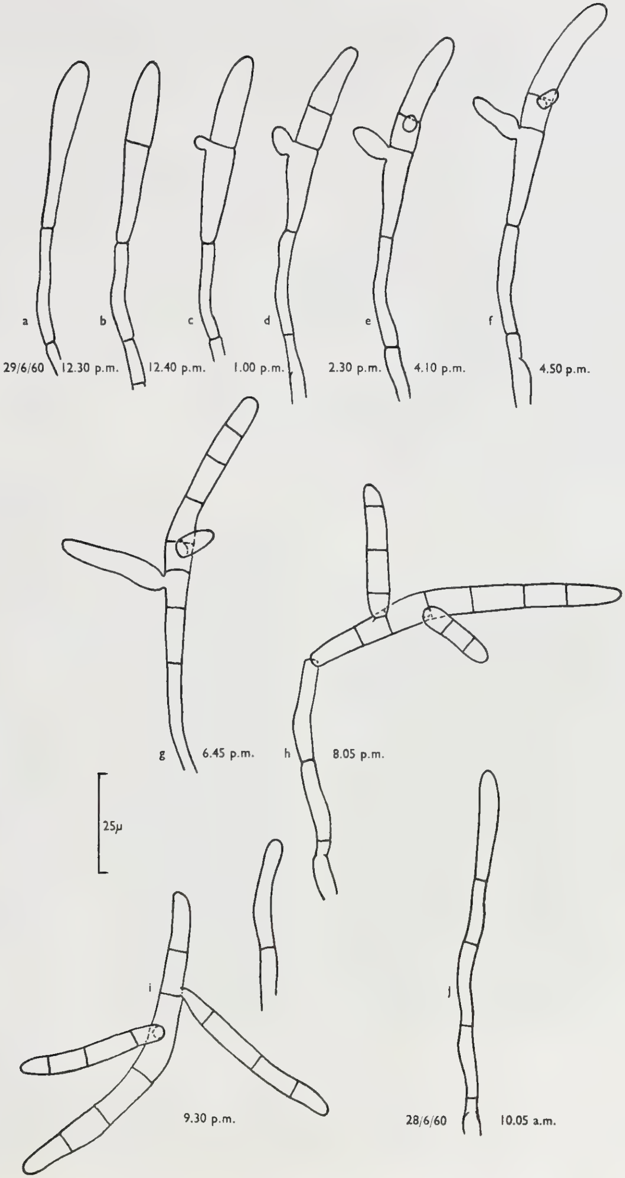


FIG. 3.—*Tricladium splendens* Ingold. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Populus nigra* var. *italica.*

(Fig. 1, a). As the primordium elongates it becomes slightly curved and a septum is formed about half-way along its length (Fig. 1, b). A protuberance which will form one of the lateral arms arises just below this septum and is constricted at its base (Fig. 1, c). A second septum forms a short distance above the first (Fig. 1, d) and a protuberance, which will form the second lateral arm, arises just below this septum and is constricted at its base (Fig. 1, e). The two lateral arms are never in the same plane. The main axis of the spore and the two laterals elongate and become further septate (Fig. 1, h). The spore is liberated by disjunction at the cross-wall separating it from the conidiophore. This pattern of development confirms that of Ingold (1942). After the first spore has been liberated the conidiophore elongates and a few cells are added to its length before another spore primordium is cut off in the same way as the first (Fig. 1, j). Spore development from the formation of the primordium to the liberation of the spore takes about eight hours. The spores germinate on 2 per cent malt agar.

Pure cultures of this fungus have been obtained by spraying spores on to the surface of 2 per cent malt agar and by transplanting them after germination. The characteristics of the culture agree with those described by Ingold (1942). The colony formed is compact with a dark olive-green central portion surrounded by a narrow white fringe. A considerable amount of dark olive-green aerial mycelium is produced. Conidia were produced when strips of culture were transferred to sterile stream water which was constantly aerated.

PLATE XXVII.

A. *Lunulospora curvula* Ingold. Conidiophore with two branches each bearing at its tip two young conidia, one almost mature and the other very young. Growing on decaying leaf of *Populus nigra* from the Belmont Valley. Mounted in acid fuchsin and lactophenol.

B. *Flagellospora curvula* Ingold. Two groups of conidiophores each consisting of a group of phialides. Spores on left young, that on right almost fully grown. Growing on decaying leaf of *Combretum caffrum* from Tyumie River. Mounted in water.

C. *Flagellospora penicillioides* Ingold. Conidiophore from culture of the fungus on 2 per cent malt agar. Mounted in water.

D. *Anguillospora longissima* (Sacc. & Syd.) Ingold. Conidiophore with conidium. Growing on decaying leaf of *Populus sp.* from the Baakens River. Mounted in water.

E. *Anguillospora filiformis* n. sp. Showing point of attachment of conidium to conidiophore and process at base of conidium. Growing on decaying leaf from the Hogsback. Mounted in water.

F. *Tricladium splendens* Ingold. Conidiophore bearing young conidium. Growing on decaying leaf of *Populus serotina* from the Hogsback. Mounted in water.

G. *Tricladium gracile* Ingold. Two conidiophores each bearing an immature conidium. Growing on decaying leaf of *Quercus robur* from the Hogsback. Mounted in water.

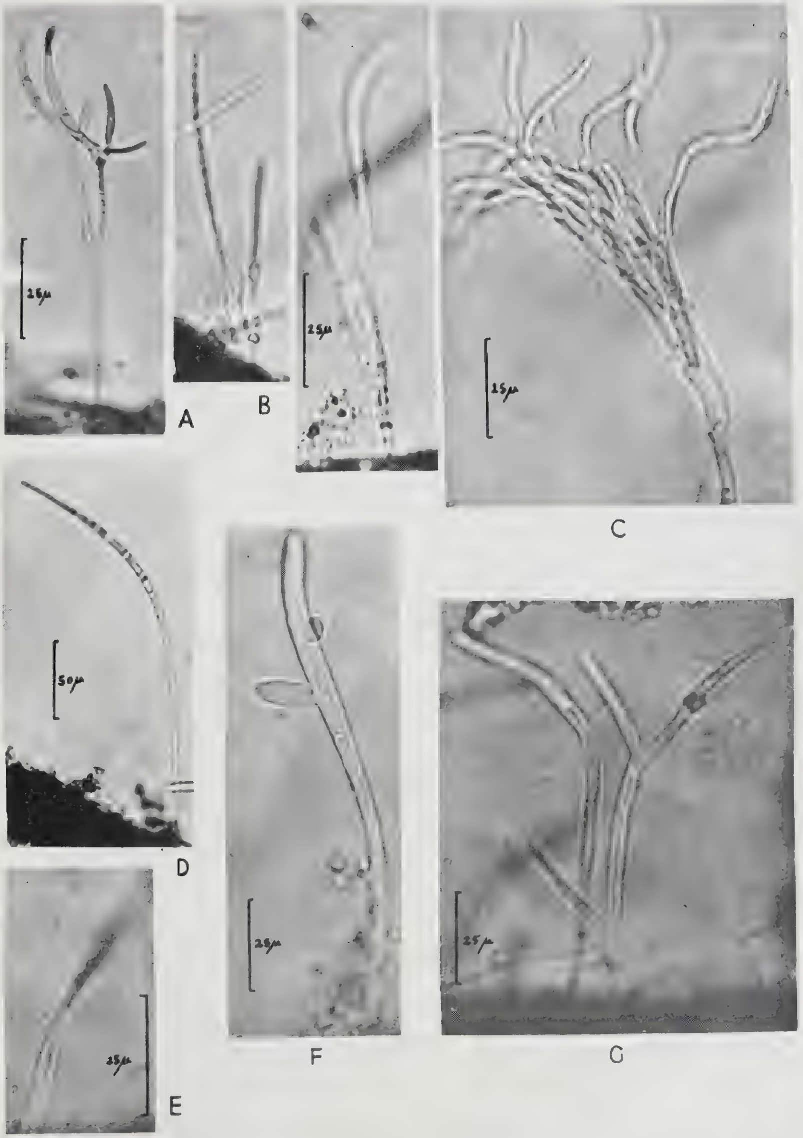


Plate XXVII

Tricladium gracile Ingold. (Plate XXVII, G.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore simple, hyaline, 10—50 μ long, 2—2·5 μ broad. Conidia (aleuriospores) terminal, solitary, hyaline, septate, branched, consisting of a main axis and two branches: main axis 90—150 μ long, 3·0—3·5 μ broad in basal half, but tapering to 1·5 μ towards the apex curved or bent to an obtuse angle at the point of origin of each lateral branch; branches straight, 50—80 μ long, 1·5 μ broad; distance between the points of origin of the two branches 14—18 μ. From submerged decaying leaves of oak from streams in Britain." (Ingold 1944.)

Other records of *Tricladium gracile* are from California (Ranzoni 1953). This fungus has been found on submerged leaf skeletons of *Populus serotina, Quercus robur, Eucalyptus globulus, Celtis africana, Rhus legati, Grewia occidentalis, Maytenus cymosus, Podocarpus latifolius, Rubus sp.* and of *Buddleja salicifolia* from the Hogsback and of *Populus nigra* from the Belmont Valley. This fungus was common in collections made in April and May and was abundant in July and August.

The fungus has been isolated on 2 per cent malt agar by spraying spores on a malt-agar plate and by subsequent sub-culturing on the same medium. The colony formed on malt agar is compact, zoned and the reverse side is a dull bluish grey at first, becoming greyish brown with age. There is a narrow white to cream border and patches of yellow staining are sometimes present. A considerable amount of light grey aerial mycelium is produced in the dark central region. When strips of the culture were transferred to sterile stream water which was constantly aerated, spores were produced but not abundantly. The conidiophores and conidia which arose from the dark cells of the old mycelium were colourless and agreed exactly with those formed in nature.

Clavariopsis aquatica De Wild. (Plate XXVIII, AB.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore usually simple, 50—250 μ long, 2—2·5 μ broad. Conidium (aleuriospore) terminal consisting of a broadly clavate, two-celled main part, 30—40 μ long, 3—4 μ broad at the base widening to 12—14 μ broad at the apex, with three long divergent processes 50—70 μ long, 1·5—2 μ broad, developed from its truncate apex." (Ingold 1942.)

In addition to this record from England, *Clavariopsis aquatica* has been recorded from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960) and from Rhodesia (Ingold 1958). This fungus has been found on submerged skeletonised leaves of *Populus serotina, Quercus robur, Xymalos monospora* and *Rubus sp.* and on a decaying fruit of *Acacia sp.* from the Hogsback and on *Populus nigra* and *Quercus robur*

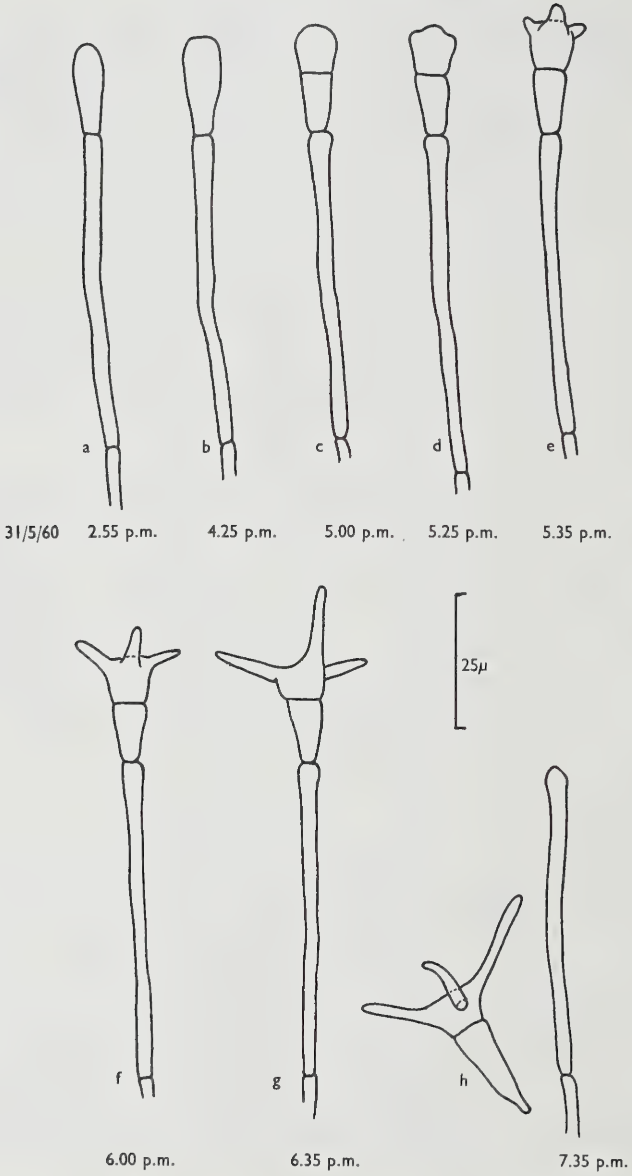


Fig. 4.—*Clavariopsis aquatica* de Wild. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Populus nigra*.

from the Belmont Valley. Spore development has been followed in hanging-drop cultures of the fungus on decaying leaves of *Populus nigra* (Fig. 4). The tip of the conidiophore swells up and a cross-wall is formed cutting off a clavate spore primordium (Fig. g 4, a). A septum forms about half-way along the length of the primordium dividing it into two cells (Fig. 4, c). Three bulges which will form the three long divergent processes appear at the distal end of the upper cell (Fig. 4, d). The spore is fully developed (Fig. 4, g) one to two hours later and is liberated by a rounding off of the two layers of the cross-wall between the spore and the conidiophore (Fig. 4, h). This pattern of development closely resembles that described by Ingold (1942). It would appear that the formation of the cross-wall which divides the spore into two cells may either take place before or after the divergent arms have started to develop. In Ingold's drawings (1942) the wall is not present until after the divergent arms are quite well developed but in this case in all the spores examined the wall was formed before the divergent arms started to develop. Some spores collected from the Belmont Valley had four divergent arms.

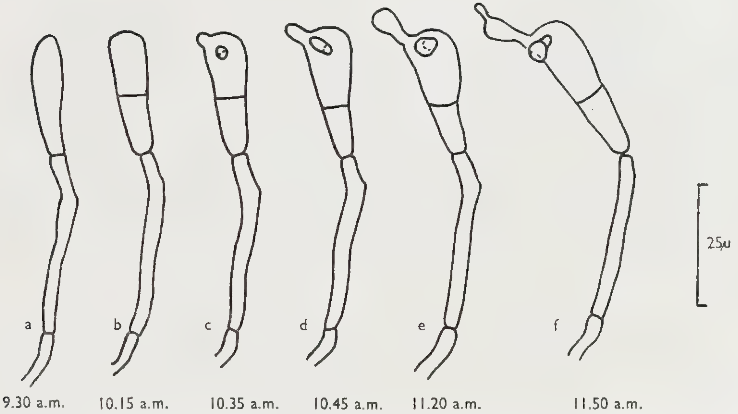


FIG. 5.—*Clavariopsis aquatica.* Abnormal spore development. From a hanging-drop culture of the fungus growing on a decaying leaf of *Populus nigra.*

Two of the spores observed in the hanging-drop culture, over a closed ring, developed abnormally. One of the spores formed was a simple two-celled spore with a small apical projection (Fig. 5) and the other had two short inflated arms, instead of the normal three long divergent arms, and one of these had a secondary process (Fig. 6).

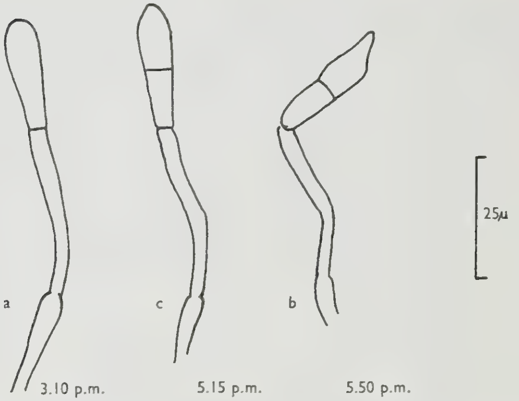


Fig. 6.—*Clavariopsis aquatica.* Abnormal spore development from hanging-drop culture of the fungus growing on a decaying leaf of *Populus nigra.*

The fungus has been isolated on 2 per cent malt agar by spraying spores on to a malt-agar plate and by subsequent sub-culturing on the same medium. The characteristics of the culture agree with those described by Ingold (1942). The colony formed is compact, with a considerable growth of white aerial mycelium over the whole colony. The reverse is dark olive-green with an irregular white fringe. When a strip of colony was transferred to water which was constantly aerated, conidiophores and conidia, which agreed exactly with those formed in nature, were produced from the dark cells of the old mycelium.

Heliscus longibrachiatus Ingold. (Plate XXVIII, C.)

"Aquatic fungus with branched septate mycelium. Conidiophores and conidia developed below water. Conidia usually simple, consisting of a simple phialide 10—20 μ long, 1·5 μ broad at the base widening to 4·0 μ at the apex, with three straight divergent arms 15—25 μ long, 1·0—1·5 μ broad arising from a truncate apex. Conidia unicellular produced in basipetal succession.

"On decaying leaves of *Alnus glutinosa* from a stream in Leicestershire, England". (Ingold 1942). *Heliscus longibrachiatus* has been found growing on skeletonised leaves of *Populus serotina, Quercus robur* and *Eucalyptus globulus* and on a decaying fruit of *Acacia sp.* from the Hogsback. This fungus was only abundant on leaves of *Eucalyptus globulus* collected in August.

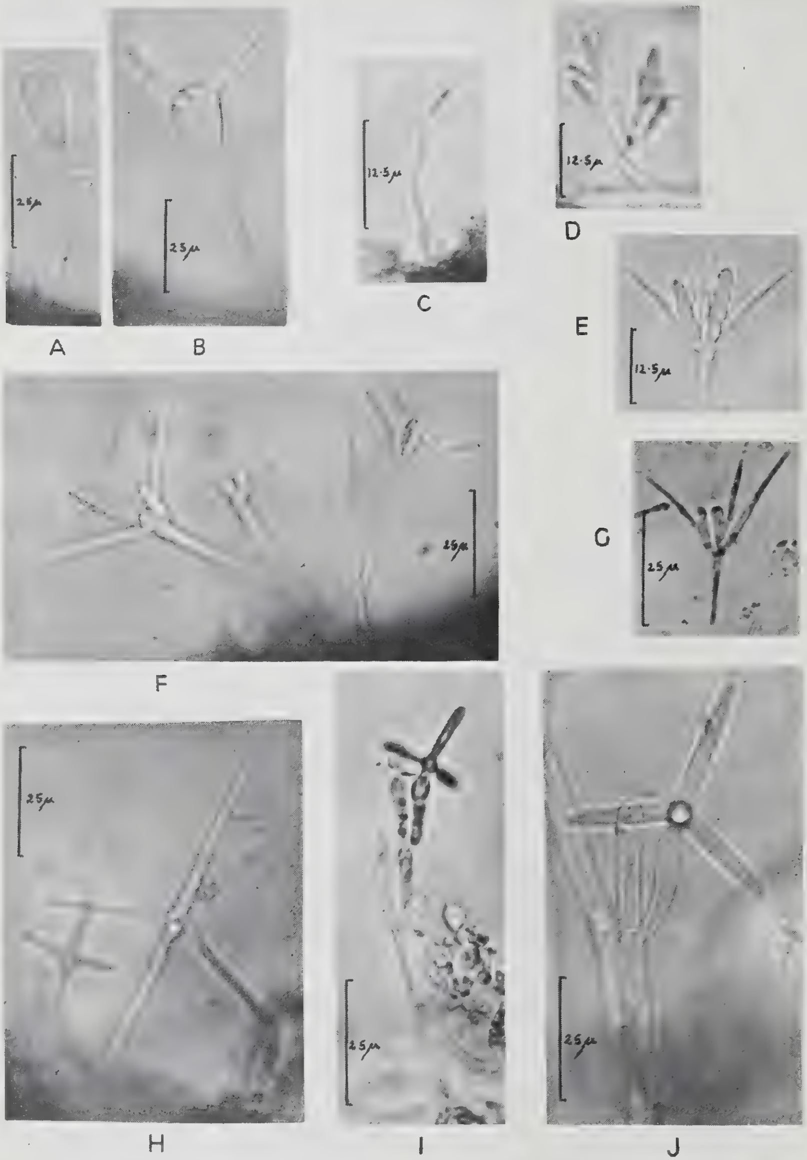


Plate XXVIII

Tetracladium marchialanum De Wild. (Plate XXVIII, F.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore sparingly branched often with two conidia at different stages of development. Conidium (aleuriospore) normally consisting of four divergent branches 20—40 μ long, 2—3 μ broad, and of two, more or less spherical knobs, 3—5 μ broad, one situated just above the point from which the four branches diverge, the other a short distance from this point on the upper side of one of these branches". (Ingold 1942).

Abnormal spores of the type described by Ingold (1942) from cultures of the fungus on malt agar have also been observed in water in which the fungus is growing on decaying leaves: one of these is illustrated in Plate XXVIII, G.

In addition to the above record of *Tetracladium marchialanum* from England it has been recorded from Switzerland (Ingold 1949), from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960) and Rhodesia (Ingold 1958). This fungus has been found growing on submerged leaf skeletons of *Populus nigra*, from the Belmont Valley and of *Salix babylonica* from Port Elizabeth, of *Combretum caffrum* from the Tyumie River and on soft but not slimy submerged leaf skeletons of *Plectranthus ecklonii* from the Hogsback. This fungus has been collected from April to August and was most abundant in July.

Spore development has been followed in hanging-drop cultures of the fungus growing on decaying leaves of *Populus nigra* (Fig. 7).

PLATE XXVIII.

A and B. *Clavariopsis aquatica* De Wild. Two conidiophores each bearing a conidium. "A" before lateral branches have formed. "B" almost mature. Growing on decaying leaf from the Hogsback. Mounted in water.

C. *Heliscus longibrachiatus* Ingold. Conidiophore with almost mature conidium. Growing on decaying leaf of *Quercus robur* from the Hogsback. Mounted in water.

D. *Tetracladium setigerum* (Grove) Ingold. Two branched conidiophores. Growing on decaying leaf of *Maytenus cymosus* from the Hogsback. Mounted in acid fuchsin and lactophenol.

E. *Tetracladium setigerum*. Liberated conidium. From Hogsback. Mounted in water.

F. *Tetracladium marchialanum* De Wild. Two conidiophores each bearing two conidia at various stages in development. The conidium on the extreme left is almost mature. Growing on leaf of *Combretum caffrum* from the Tyumie River. Mounted in water.

G. *Tetracladium marchialanum*. Abnormal conidium from Baakens River. Mounted in water.

H. *Triscelophorus monosporus* Ingold. Three conidiophores. The spore in the centre is almost mature. Growing on leaf of *Populus nigra* from the Belmont Valley. Mounted in water.

I. *Lemonniera aquatica* De Wild. Conidiophore growing on decaying leaf of *Populus serotina* from the Hogsback. Mounted in acid fuchsin and lactophenol.

J. *Lemonniera brachycladia* Ingold. Conidiophore with two phialides. Growing on decaying leaf of *Celtis africana* from the Hogsback. Mounted in water.

The spore primordium elongates and a small apical knob-like cell is cut off by a septum. A protuberance which will form the second divergent arm on the second knob of the spore appears just below this septum (Fig. 7, d). A second protuberance which will form the third divergent process appears on the opposite side of the knob (Fig. 7, g). On the side of the first protuberance there appears a third protuberance which will form the fourth divergent arm (Fig. 7, h, B). The mature spore is formed by further growth of its branches (Fig. 7, h-k, B) and is liberated by the apparent dissolution of the middle lamella of the wall separating it from the conidiophore (Fig. 7, 1). This pattern of development agrees with that described by Ingold (1942). The development of a spore from the formation of the primordium to the liberation of the spore takes about nine to ten hours.

Ingold (1942) noted that "while the developing spore is still young, usually when its first arm is beginning to grow out, the conidiophore gives rise to a branch a short distance below the first spore. This branch is soon cut off by a wall near its base and is the primordium of the new spore". Then after the first spore is liberated "while the second spore is still developing a new hypha grows out from the stump from which the first has separated. This usually arises slightly to one side of the stump. It is soon cut off by a cross-wall and is the primordium of the third spore". However, it was found that, though a branch may be produced a short distance below a developing spore, it may alternatively be produced slightly to one side of a developing spore, while it is still young. In the material examined it was more usual for a spore primordium to be produced next to a young spore than for it not to be developed until after the first spore was shed (Fig. 7a, gA).

The spores germinate readily on 2 per cent malt agar and in stream water. Pure cultures of this fungus have been obtained by spraying spores onto the surface of 2 per cent malt agar and by transplanting them after germination. The characteristics of the culture correspond to those described by Ingold (1942). The colony formed is compact, white to a pale pinkish yellow and zoned. There is a considerable zonal growth of white aerial mycelium. When strips of culture were transferred to sterile stream water, which was constantly aerated, spore primordia were produced abundantly within 18 hours and after 22 hours mature spores had developed.

Tetracladium setigerum (Grove) Ingold. (Plate XXVIII, D, E.)

"Aquatic fungus with branched septate mycelium. Conidium (aleuriospore) consisting of four divergent arms 20—40 μ long, each tapering from 3 μ near the central region of the spore to 1 μ near its tip, and of

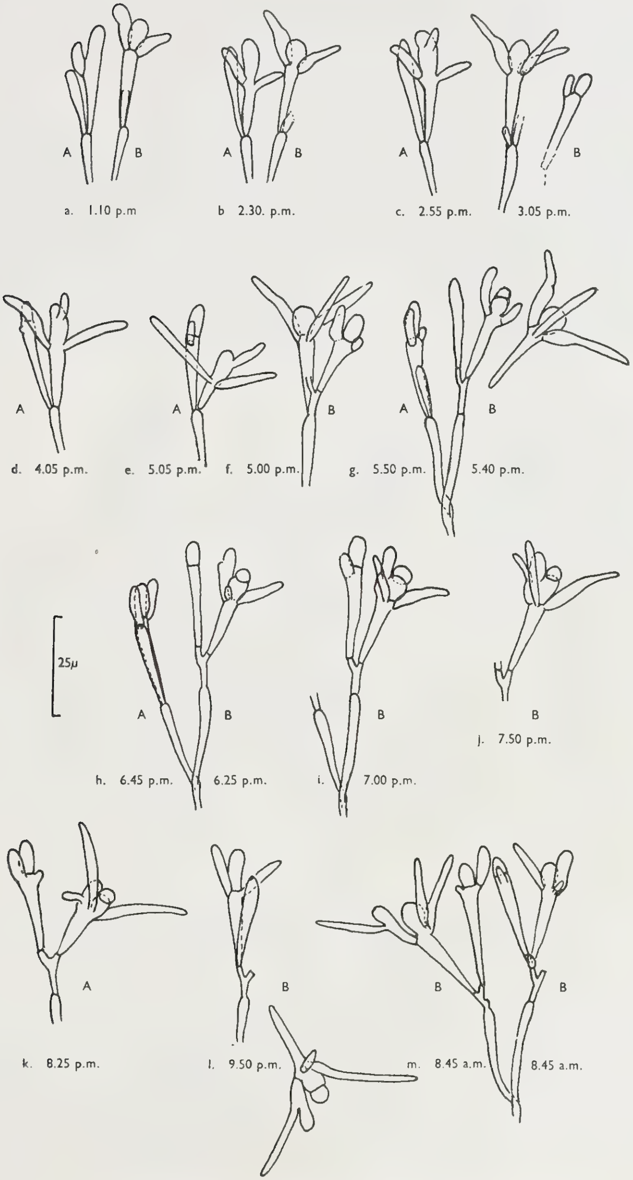


FIG. 7.—*Tetracladium marchialanum* de Wild. Spore development. From hanging-drop culture growing on a decaying leaf of *Populus nigra.*

three elongated, parallel, finger-like processes, 12—15 μ long, 3—9 μ broad, two of which are inserted just above the point of divergence of the four arms and the third a short distance along one of the arms". (Ingold 1942).

In addition to this record of *Tetracladium setigerum* from England it has been recorded from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960), Switzerland (Ingold 1949) and Rhodesia (1958) This fungus has been found growing on submerged leaf skeletons of the exotic tree *Populus serotina* and an indigenous tree *Maytenus cymosus* from the Hogsback. Spore development was followed in a hanging drop culture of the fungus growing on a decaying leaf of *M. cymosus* (Fig. 8) and confirmed the pattern of development deduced by Ingold (1942) from examination of conidia at various stages in their development.

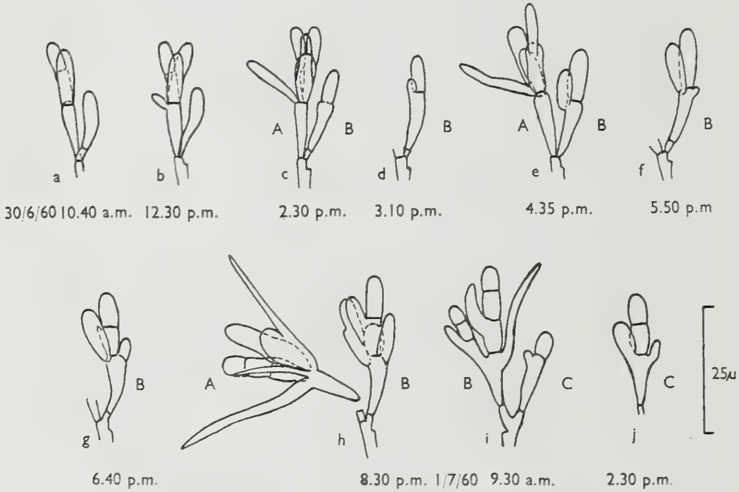
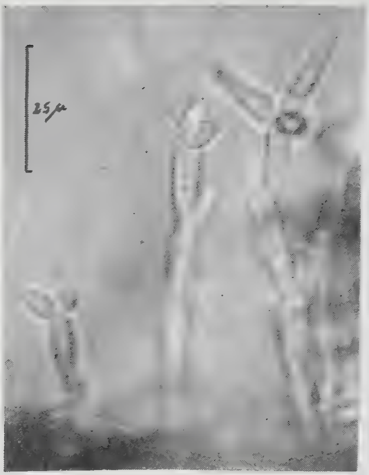
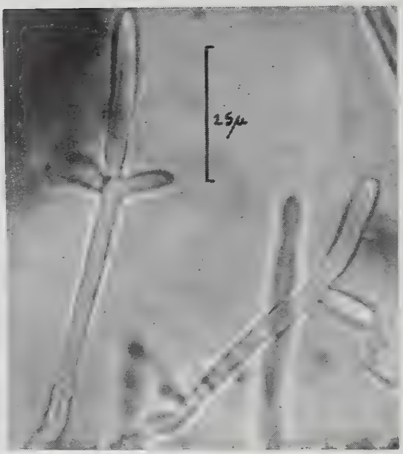


Fig. 8.—*Tetracladium setigerum* (Grove) Ingold. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Gymnosporia buxifolia.*

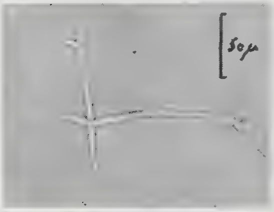
The first spore primordium is terminal on the conidiophore but, while this spore is still young, a short branch bearing a second primordium may be produced either beside the first spore or on a short branch which arises slightly below it. The primordium is cut off from the conidiophore by a septum and is in the form of a long slightly swollen cell (Fig. 8a). Towards the apex of this cell a septum forms, cutting off a small apical cell (Fig. 8, c) which will give rise to two of the finger-like processes and



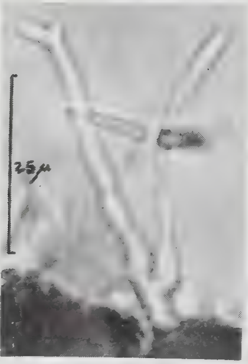
A



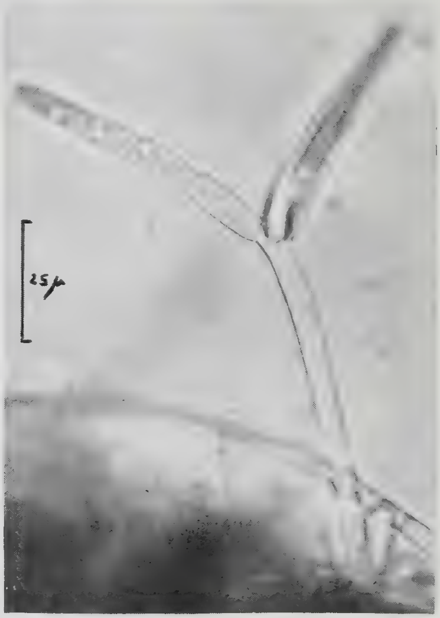
C



B



E



D

PLATE XXIX

a large lower cell which is the first divergent arm. Soon afterwards a small protuberance, which will give rise to the third finger-like process and one of the divergent arms, appears slightly below and to one side of the septum (Fig. 8, d). As it grows, this process bends upwards, more or less parallel with the small apical cell which is also elongating. The apical cell becomes constricted about half-way along its length and a septum is formed at this level. Shortly afterwards, slightly below this septum, there appears a protuberance which becomes the second finger-like process (Fig. 8, g). While the first finger-like process is elongating, a protuberance which will form the third divergent arm appears slightly below the septum cutting off the first process and on the side away from the third process (Fig. 8, f). A protuberance which will form the fourth divergent arm appears at the same level as the third but between it and the third finger-like process (Fig. 8, h). Shortly after this, on the side of the third finger-like process about half-way along its length on the side away from the other two, there appears a protuberance which will form the second divergent arm (Fig. 8, h). A septum forms just above this protuberance across the third finger-like process which, like the other finger-like processes, may become further septate above the points of branching (Fig. 8, i). Liberation of the spore seems to take place, as in *Tetracladium marchialanum*, by solution of the middle lamella separating the spore from the conidiophore.

Articulospora tetracladia Ingold. (Plate XXIX, A.)

"Submerged aquatic fungus with branched, septate, hyaline mycelium. Conidium (aleuriospore) hyaline, of four divergent arms: the first formed arm 20—35 μ long, 3 μ broad, 1—2 septate, each with a narrow constriction or isthmus, where it joins the short arm. In the formation of the spore the four arms arise in succession. Conidiophore simple or

---

PLATE XXIX

A. *Articulospora tetracladia* Ingold. Three conidiophores bearing conidia at various stages in development. Growing on decaying leaf of *Celtis africana* from Paradise Kloof. Mounted in water.

B. *Articulospora tetracladia*. Germinating conidium. Two germ tubes have developed into conidiophores on each of which a conidium has formed. From the Hogsback. Mounted in water.

C. *Articulospora grandis* n. sp. Conidia at various stages of development. Growing on decaying leaf of *Celtis africana* from Paradise Kloof. Mounted in water.

D. *Articulospora grandis* n. sp. Conidiophore with immature conidium. Growing on a decaying leaf of *Celtis africana* from Paradise Kloof. Mounted in water.

E. *Alatospora acuminata* Ingold. Branched conidiophore with two phialides each bearing a conidium. The conidium on the right is almost mature. Growing on a decaying leaf of *Maytenus cymosus* from the Hogsback. Mounted in water.

branched, producing spores from its apex (or apices) in succession, not basipetal but side by side. On decaying leaves of *Alnus glutinosa* from a stream in Leicestershire, England." (Ingold 1942.)

Other records of *Articulospora tetracladia* are from California (Ranzoni 1953), from Jamaica (Hudson and Ingold 1960), from Switzerland (Ingold 1949) and from Rhodesia (Ingold 1958). This fungus has been found from April to August growing on submerged leaf skeletons of *Populus serotina* from the Hogsback, of *Quercus robur* from the Hogsback and from Featherstone Kloof, *Celtis africana* from Paradise Kloof and from the Hogsback, *Rhus legati* from Howiesons Poort and from the Hogsback and *Maytenus cymosus* from the Hogsback.

Spore development was followed in hanging-drop cultures of the fungus growing on decaying leaves of *Celtis africana* (Fig. 9).

The spore primordium develops as an outgrowth from the tip of the conidiophore and is cut off from the conidiophore by a septum. It then elongates and becomes constricted a short distance below its apex (Fig. 9, i). The portion below the constriction is the first arm and the portion above the constriction will form the second arm. Soon afterwards on the side of the first arm just below the constriction there appears a protuberance which is constricted at its base and will form the third arm (Fig. 9, j). The fourth arm develops from a second protuberance which appears to one side of the third arm just below the constriction between the first and second arms (Fig. 7, l). When the spore is mature it is liberated by separation along the middle lamella of the septum between the spore and the conidiophore (Fig. 7, g, n). The development of a spore, under laboratory conditions, from the formation of the primordium to liberation of the spore, may take up to twenty-two hours. This confirms the account of spore development by Ingold (1942). Spores with only three arms are sometimes developed (Fig. 7, g). Before the spore has completed developing, at one side of it on the end of the conidiophore, a new spore primordium is developed or an outgrowth is produced which elongates and is divided by a septum into a spore primordium and a conidiophore cell.

The spores germinate readily in water and on 2 per cent malt agar. A germinating spore was found in which two of the germ tubes had developed into conidiophores bearing conidia (Plate XXIX, B). These conidia were much smaller than normally produced conidia.

The fungus has been isolated on 2 per cent malt agar by spraying spores on to a malt-agar plate and by subsequent sub-culturing on the same medium. The colony formed is compact, white with a fair amount of cottony aerial mycelium, zoning occurs near the edge of the colony. Conidiophores are produced after twenty-four to thirty-three hours and

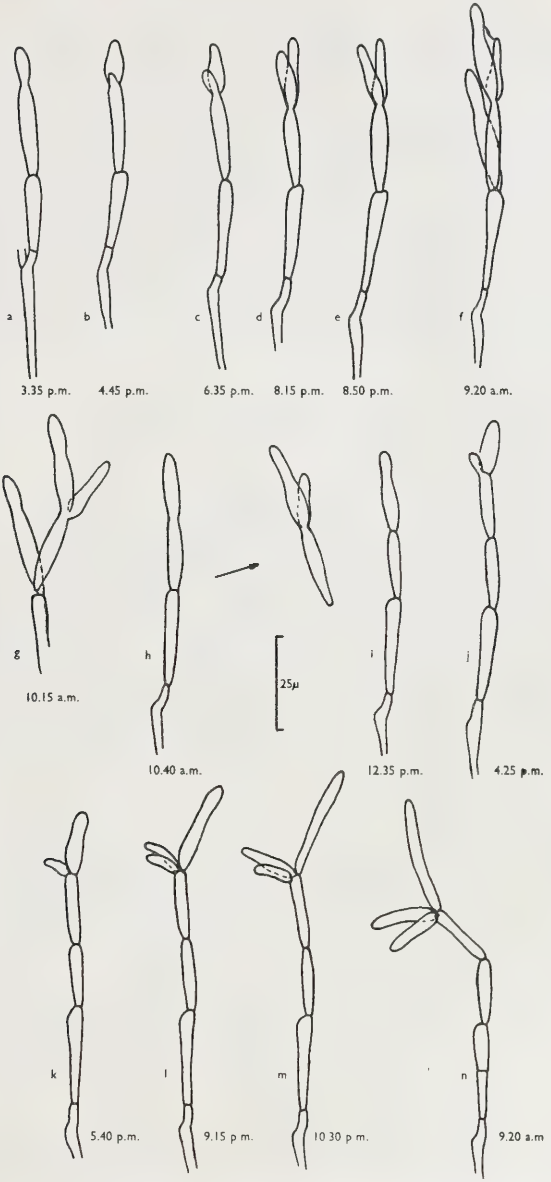


FIG. 9.—*Articulospora tetracladia* Ingold. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Celtis africana*.

the conidia produced agree with those formed in nature. This confirms the observations of Ingold (1942).

Articulospora inflata Ingold.

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore usually simple, 40—50 μ long, 3—4 μ broad, sometimes sparingly branched. Conidia (aleuriospores) hyaline, terminal, solitary, septate, quadraradiate: first formed arm continuous with the conidiophore 50—70 μ long, 3—4 μ wide, with the uppermost region (from which the other arms arise) slightly inflated: second formed arm not constricted at its base, 50—120 μ long, 3—4 μ broad; third and fourth arms 50—120 μ long, 3—4 μ broad, constricted at the base to 1·5—2 μ. On submerged decaying leaves of sycamore and oak from a stream near Leeds, England." (Ingold 1944.)

A fungus closely resembling this species has been found at Howiesons Poort on an unidentified decaying leaf from the Hogsback on a skeletonised leaf of *Populus serotina.*

Articulospora grandis n. sp. (Plate XXIX, C, D).

Submerged aquatic fungus with branched, septate, hyaline mycelium. Conidiophore hyaline, simple. Conidia (aleuriospores) produced in basipetal succession, hyaline, of four divergent arms: the first formed arm is 66—87 μ long, 6—9 μ broad at base, 0·4 μ broader at junction with the other arms; 3—7 septate; the other three arms 55—100 μ long, 9—11 μ broad at the base tapering to 5—7 μ broad at the distal ends; 3—7 septate: each constricted where it joins the first formed arm. In the formation of the spore the four arms arise in succession.

Hab. On submerged decaying leaves from streams in the Eastern Cape Province of South Africa.

Articulospora grandis sp. nov.

Fungus aquaticus, submersus, mycelio ramoso, septato, hyalino. Conidiophora hyalina, simplicia. Conidia (aleuriosporae) continua, ex eodem loco deinceps exorientia, hyalina, quadriradiata, quattuor radiis diversis. Radius primarius 66—87 μ longus, parte inferiore ad 6—9 μ latus, parte superiore ad 0·4 μ latior, 3—7 septatus. Radii ceteri 55—100μ longi, parte inferiore ad 9—11 μ lati, ad apicem ad 5—7 μ attenuati, 3—7 septati, unusquisque constrictus ubi radio primario conjungitur. In sporo formando quattuor illi radii continui deinceps evolvuntur.

Hab. In foliis putrescentibus, in fluminibus in orientale parte Capicae Provinciae Africae Australis submersis.

Articulospora grandis was found from June to August on submerged decaying leaves of *Celtis africana* from a stream in natural forest near Grahamstown and of *Rapanea melanophloeos* from Howiesons Poort.

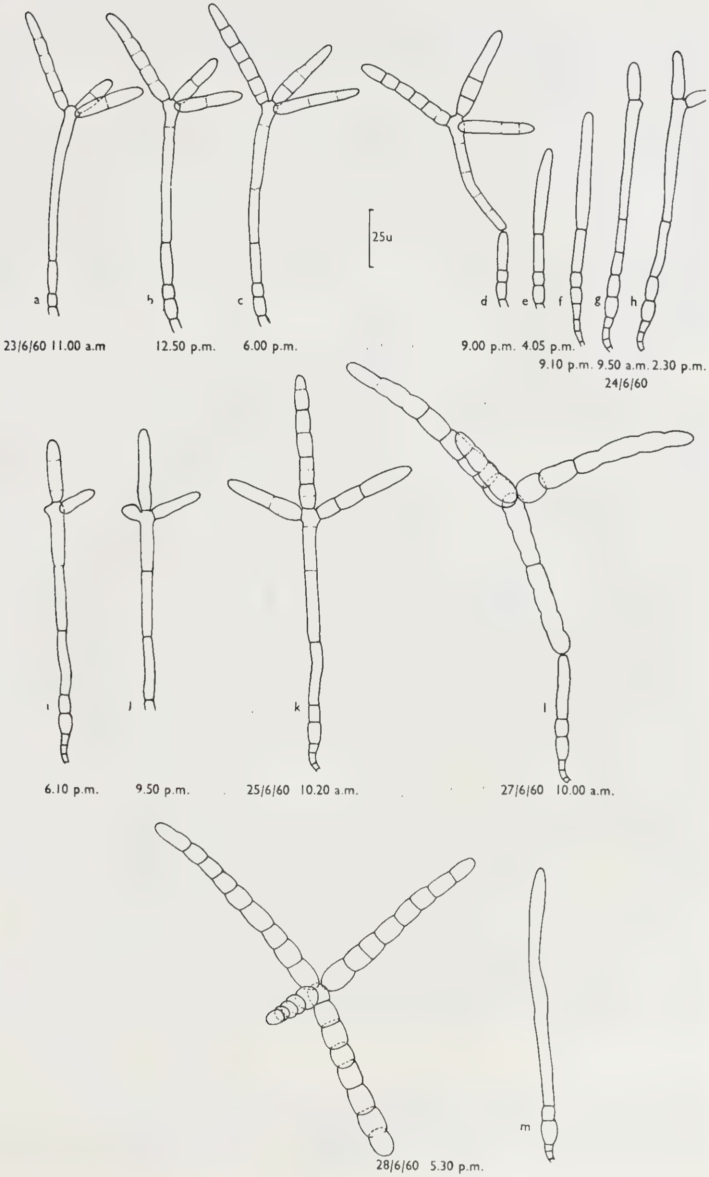


Fig. 10.—*Articulospora* sp. Spore development. From hanging-drop culture of the fungus on a decaying leaf of *Celtis africana*.

This fungus agrees with the general description of the genus *Articulospora* (Ingold 1942) but differs from the described species. The spores are larger than those of *Articulospora tetracladia* and are produced in basipetal succession in this fungus and side by side from the end of the conidiophore in *A. tetracladia*. Although the lengths of the arms of *A. grandis* correspond to those of *A. inflata* the arms are much broader than those of *A. inflata*, 9—11 μ broad at the base and 5—7 μ broad at the distal ends compared with 3—4 μ. Further, the second arm is constricted at the base in this fungus but not in *A. inflata*. The spores of this fungus differ from those of *A. moniliforma* Ranzoni in that they are much larger and the arms of the spore do not taper to a point at their distal ends as they do in the latter.

Spore development has been followed in hanging-drop cultures of the fungus growing on a decaying leaf of *Celtis africana* (Fig. 10).

The spore primordium is cut off from the conidiophore by a septum (Fig. 10, e). It is a long cell approximately the same width as the conidiophore. The primordium elongates and becomes constricted a short distance below the apex. A septum is formed in this region cutting off the primordium of the second arm (Fig. 10, g). A protuberance which will form the third arm appears just below and to one side of the septum. As the protuberance grows out, it becomes constricted at its base and a septum forms across this constriction (Fig. 10, h). A second protuberance which will form the fourth arm appears below and to one side of the second arm on the opposite side of the first arm (Fig. 10, j). This becomes constricted at the base and is cut off by a septum which forms across the isthmus (Fig. 10, k). The four arms of the spore are now delimited about 42 hours after the primordium was cut off from the conidiophore. The arms continue to increase in length and width, with the constriction at the base of the second, third and fourth arms becoming more marked. The arms become constricted at intervals along their length and septa start to form across these constrictions (Fig. 10, k, l). The spore is then liberated by the rounding off of the tip of the conidiophore and of the basal end of the first arm about 66 hours after the formation of the primordium. After the spore has been liberated, septum formation and increase in size continue (Fig. 10, m). The conidiophore elongates and another spore primordium is cut off but unlike *Tricladium splendens* no cells are added to the conidiophore. The spores germinate on 2 per cent malt agar.

Alatospora acuminata Ingold. (Plate XXIX, E.)

"Submerged aquatic fungus with branched, septate mycelium. Conidiophore usually unbranched consisting of a single phialide 10—20 μ long, 2—3 μ broad, but often branched producing a group of two to four phialides. Conidium (phialospore) unicellular, hyaline, consisting of four divergent and approximately equal arms, 15—35 μ long, 1·5—2·5 μ broad, tapering towards their apices. Conidia produced in basipetal succession from the phialide. On decaying leaves of *Alnus glutinosa* and *Salix sp.* from a stream in Leicestershire, England." (Ingold 1942.)

Other records of *Alatospora acuminata* are from Switzerland (Ingold 1949), California (Ranzoni 1953), Jamaica (Hudson and Ingold 1960) and Rhodesia (Ingold 1958). This fungus has been found growing on submerged decaying leaves of *Populus serotina, Quercus robur, Eucalyptus globulus, Grewia occidentalis, Maytenus cymosus, Calodendrum capensis, Podocarpus latifolius; Polystichum sp., Rubus sp.* and *Buddleja salvifolia* from the Hogsback; *Rhus legati* from Howiesons Poort; *Celtis africana* from Paradise Kloof; *Combretum africanum* from the Tyumie River and on a submerged decaying fruit of *Acacia sp.* from the Hogsback. Spores with five arms have been found to be produced though not frequently by the fungus growing on *Maytenus cymosus.*

Spore development has been followed in hanging-drop cultures of the fungus growing on a decaying leaf of *Maytenus cymosus* (Fig. 11).

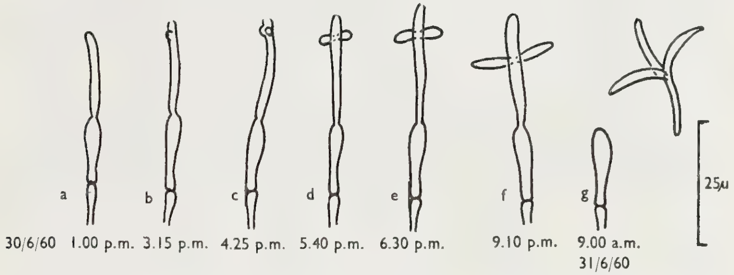


Fig. 11.—*Alatospora acuminata* Ingold. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Gymnosporia buxifolia.*

The spore primordium grows out from the apex of the phialide as a straight hypha which bends over near the tip. Two bulges appear simultaneously close together on the convex curve of the hypha. These two bulges elongate to form two arms of the spore. This confirms the observations of Ingold (1942). The spores germinate on 2 per cent malt agar.

Triscelophorus monosporus Ingold. (Plate XXVIII, H.)

"Submerged aquatic fungus with branched, septate, mycelium. Conidiophore hyaline, simple, straight, 15—45 μ long, 1·5 μ broad, producing a single terminal conidium. Conidia (aleuriospores) hyaline branched, aseptate (or with a single septum in the main axis just above the point of origin of the lateral branches): main axis continuous with the conidiophore, 50—70 μ long, 4—5 μ broad (at a distance of 3—5 μ from the base) tapering to 1·5 μ at the truncate base; secondary ramuli in a whorl of three, arising at a distance of 3—5 μ from the base of the main axis, 40—50 μ long, 2·0—2·5 μ broad near the base tapering to 1·5 μ at the apex, base abruptly constricted to 1μ. On a submerged decaying leaf from the river Loddon near Reading, England." (Ingold 1943.)

Other records of *Triscelophorus monosporus* are from California (Ranzoni 1953), Jamaica (Hudson and Ingold 1960), Rhodesia (Ingold 1958), Nigeria (Ingold 1956) and Ghana (Dixon 1959). This fungus has been found growing on submerged leaf skeletons of *Populus nigra* from the Belmont Valley, *Combretum caffrum* from the Tyumie River, on sub-

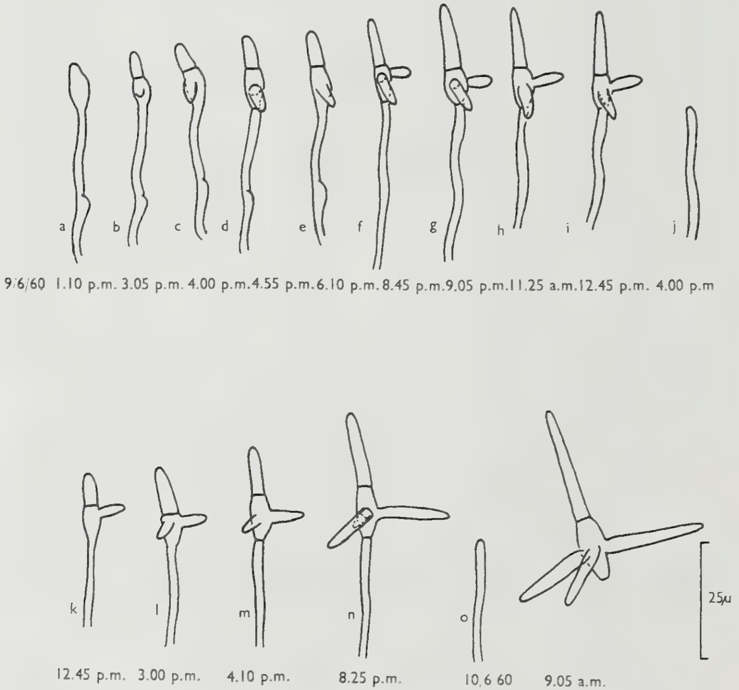


Fig. 12.—*Triscelophorus monosporus* Ingold. Spore development. From hanging-drop culture of fungus growing on a decaying leaf of *Rhus legati*.

merged decaying leaves of *Rhus legati* from Howiesons Poort and on a submerged decaying fruit of *Acacia sp.* from the Hogsback.

Spore development has been followed in a hanging-drop culture of the fungus growing on a decaying leaf of *Rhus legati* (Fig. 12).

The spore primordium starts as a swelling at the tip of a conidiophore. The swelling enlarges and becomes differentiated into a wide lower portion and a slightly narrower upper portion (Fig. 12, a). These two parts become separated by a septum. From the middle of the lower portion a protuberance appears and grows outwards to form one of the three lateral branches (Fig. 12, b). The upper part of the spore continues to elongate. A second protuberance which will form the second lateral branch arises at the same level but at an angle of about 120° from the first (Fig. 12, f). At about this stage in development the spore is cut off from the conidiophore by a septum. The third lateral branch arises as a protuberance at an angle of about 120° from both the other lateral branches. The spore increases in size and is liberated, when fully grown, by the separation of the middle lamella of the cross-wall between the spore and the conidiophore (Fig. 12, o). This confirms the account given by Ingold (1943), except that he found that the spore primordium was cut off from the conidiophore early in its development, whereas it would appear that the septum is not necessarily formed until after the second of the three laterals has been formed.

Lemonniera aquatica De Wild. (Plate XXVIII, I.)

"Submerged aquatic fungus with branched septate mycelium: conidiophore consisting of a straight unbranched portion which branches near its free end to form a group of two to eight phialides. Each phialide produces conidia (phialospores) in basipetal succession. Conidium consisting of four long divergent arms (which usually become septate), 20—70 μ long, 3—4 μ broad, and inserted on the phialide at the point of divergence of the four arms of the spore." (Ingold 1942.)

Records of *Lemonniera aquatica* are from England (Ingold 1942), Switzerland (Ingold 1949) and California (Ranzoni 1953). This fungus was found growing on submerged skeletonised leaves of *Populus nigra*, *Xymalos monospora* and *Maytenus cymosus* from the Hogsback.

Spore development has been followed in hanging-drop culture of the fungus growing on a decaying leaf of *Populus serotina* (Fig. 13).

The spore primordium starts as a small swelling at the end of the phialide (Fig. 13, d). This swelling enlarges (Fig. 13, a), becomes tetrahedral (Fig. 13, b, c) and the four arms grow out simultaneously from the corners of the tetrahedron (Fig. 13, d). When the spore is fully developed a line of cleavage forms separating it from the phialide and it is

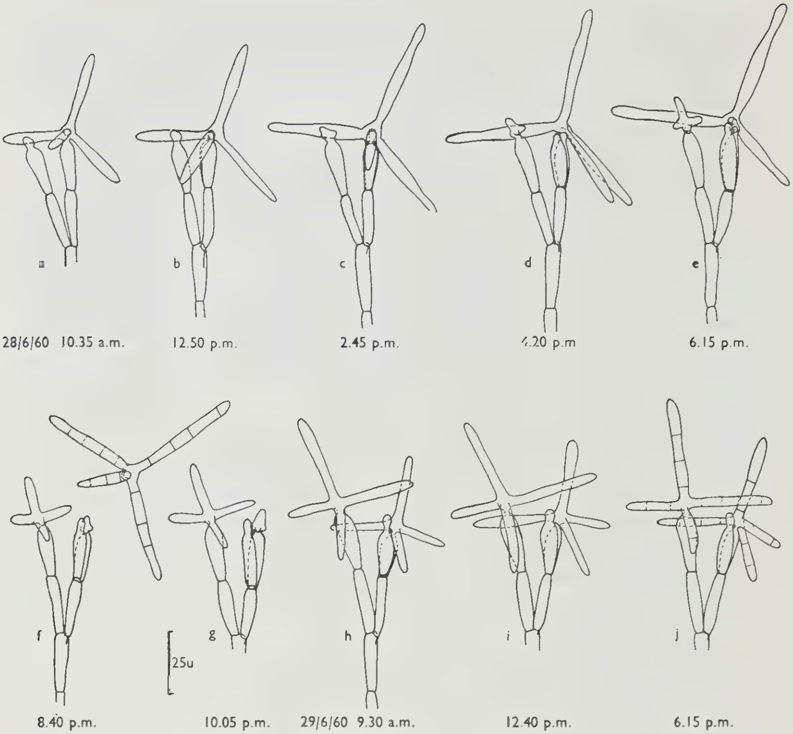


FIG. 13.—*Lemonniera aquatica* de Wild. Spore development. From hanging-drop culture of the fungus growing on a decaying leaf of *Populus nigra*, var. *italica*.

soon liberated. Just before (Fig. 13, j) or just after (Fig. 13, f) liberation the arms of the spore become septate. Immediately after a spore has been liberated a new spore primordium is formed from the tip of the phialide (Fig. 13, d). This account of spore development confirms that of Ingold (1942).

Lemonniera brachycladia Ingold. (Plate XXVIII, J.)

The following is a translation from the Latin description by Ingold (1958): Submerged aquatic fungus, mycelium branched, septate, hyaline at first, later brown. Conidiophore hyaline, septate, ending in one or many phialides. Conidium (phialospore) hyaline, consisting of four equal diverging branches arising from the first formed central portion. Each branch 15—50 μ long, 4—6 μ broad near the base narrowing to 3 μ at the apex, mostly aseptate, rarely uniseptate. Hab. on decaying leaves of *Alnus glutinosa*, etc., in running streams, Ide Hill, Kent, England.

Lemonniera brachycladia was found growing on submerged leaf skeletons of *Rhus legati*, *Calodendrum capensis* and *Buddleja salvifolia* from the Hogsback.

NOTES ON ECOLOGY

An investigation has been made of decaying plant material from streams, stagnant pools in dry river beds, ponds and dams. The aquatic hyphomycetes described in this paper were found in streams but not in any of the other habitats. The only stream site in which they were not found was the Blaaukrantz River, a mile or two below the outflow of the sewage effluent into the stream. A bacterial count was made at this site and it was found to be high. As conidial production in these fungi has been observed to be most abundant on leaf skeletons which are free from bacteria, it seems probable that the large bacterial population in this stream is responsible for these aquatic hyphomycetes being absent from an otherwise apparently suitable site. The fall in the production of conidia by the fungi on leaves kept in the laboratory, particularly when they were in unaerated water, was accompanied by an increase in bacteria. It would therefore appear that the reason for these fungi showing a preference for well aerated running water is in part due to the bacterial population being smaller than in poorly aerated stagnant water.

The pH of the water in most of the streams, where these fungi have been found, has been measured and is about 7·0. The water from the stream in Howiesons Poort had the lowest pH, 6·5, and that from the stream in the poplar plantation at the Hogsback had the highest pH, 8—8·5.

There does not seem to be a tendency for one of these fungi to become established on a leaf skeleton to the exclusion of the others. As many as seven species of these fungi—*Tricladium gracile*, *Clavariopsis aquatica*, *Anguillospora longissima*, *Tricladium splendens*, *Flagellospora curvula*, *Alatospora acuminata* and *Lunulospora curvula*—have been found growing on one square centimetre of a skeletonised leaf of *Rubus sp.* from the Hogsback. It is, however, more usual to find from one to three species on a leaf skeleton.

A wide range of decaying leaves are colonised by these aquatic hyphomycetes—a fern, *Polystichum sp.*; a Gymnosperm, *Podocarpus latifolius*; leaves of herbs, such as *Plectranthus ecklonii*, which form soft leaf skeletons; leaves of trees, such as *Celtis africana* and *Rhus legati* with relatively thin cuticles which disintegrate during skeletonisation; and of trees, such as *Eucalyptus globulus*, with thick cuticles which persist when the leaf is skeletonised. Some of these fungi have also been found on a decaying fruit of *Acacia sp.* in which the main veins were exposed.

The position in which the conidiophores are produced on the decaying leaf varies. The conidiophores may arise at right angles to the petioles, veins or leaf margins. Conidiophores occur with equal frequency on veins and leaf margins in *Tetracladium setigerum*, *Flagellospora curvula* and *Tricladium gracile*, on both veins and margins but more frequently on veins in *Lunulospora curvula*, most frequently on the margins of leaves which are not fully skeletonised in *Triscelophorus monosporus*, *Alatospora acuminata* and *Heliscus longibrachiatus* and more frequently on veins and petioles than on margins in *Clavariopsis aquatica*, *Lemonniera aquatica*, *L. brachycladia*, *Anguillospora longissima*, *Tricladium splendens*, *T. marchialanum*, *Articulospora tetracladia* and *A. grandis*.

As these fungi have as yet only been collected between April and August, no definite statements can be made as to seasonal fluctuations. However, the observations for *Lunulospora curvula* and *Alatospora acuminata* seem worth noting as they show a correspondence with Ingold's (1942) observations for these fungi in England. *Lunulospora curvula* was abundant in autumn, April and May, but showed a marked decrease in the winter months, July and August. Ingold (1942) noted that in England "this handsome fungus was found very abundantly on decaying submerged alder and willow leaves, especially during late summer and autumn. During winter and spring it was rather rare". *Alatospora acuminata* was not found in the autumn months, April, May and June, but was found in the winter months, July and August, and was particularly abundant in August. Ingold (1942) found that in England "it was especially common during the winter and spring, but much less frequent during the summer and autumn".

KEY TO THE SOUTH AFRICAN SPECIES OF AQUATIC HYPHOMYCETES

This key is merely intended as a guide to the identification of those aquatic hyphomycetes described in this paper, as it is probable that the key represents only a small number of the fungi of this type which occur in South Africa. *Campylospora* has also been included in the key, as one spore of a fungus in this genus was found in water from a stream at the Hogsback.

(1) Spores branched .. .. (6)
Spores unbranched .. .. (2)

(2) Spores crescent-shaped .. .. *Lunulospora curvula*
Spores not crescent-shaped .. .. (3)
(3) Spores unicellular or bicellular: phialospores .. .. (4)
Spores multiseptate: aleuriospores .. .. (5)
(4) Spores less than 60 μ long .. .. .. *Flagellospora penicilliodes*
Spores greater than 100 μ long .. .. .. *Flagellospora curvula*
(5) Spores 5—6 μ broad in middle region tapering towards both ends: no projection at base .. .. *Anguillospora longissima*
Spores 3·8 μ broad tapering slightly at apex only: projection near base .. .. *Anguillospora filiformis*
(6) Spores consisting of a main axis with two branches arising at different levels .. .. (7)
Spores not as above .. .. (8)
(7) Main axis 6—7 μ broad at widest part .. .. *Tricladium splendens*
Main axis 3·0—3·5 μ broad at widest part .. .. *Tricladium gracile*
(8) Spore consisting of a clavate portion from which branches arise at the broad end .. .. (9)
Spore not as above .. .. (10)
(9) Clavate part of spore 30—40 μ long .. .. *Clavariopsis aquatica*
Clavate part of spore 10—20 μ long .. .. *Heliscus longibrachiatus*
(10) Spore asymmetric, consisting of a basal cell with two divergent appendages and a lateral branch with two divergent appendages .. .. *Campylospora*
Spores not as above .. .. (11)
(11) Spore with branches of more than one type .. .. (12)
Spore with branches all of one type .. .. (13)
(12) Spore consisting of four divergent arms and three finger-like processes .. .. *Tetracladium setigerum*
Spore of four divergent branches and two more or less spherical knobs .. .. *Tetracladium marchialanum*
(13) Spore with one of the arms bearing three other arms at its apex .. .. (14)
Spores not as above .. .. (16)
(14) Arm bearing the other three arms inflated at its apex *Articulospora inflata*
Arm bearing the other three arms not inflated at apex .. .. .. (15)
(15) Branches of spore 36—75 μ long, 3 μ broad, spores produced side by side at apex of conidiophore .. *Articulospora tetracladia*
Branches of spore 55—100 μ long, 4—11 μ broad at base: spores produced singly from apex of conidiophore *Articulospora grandis*
(16) Spore consisting of a curved axis bearing a pair of opposite arms .. .. *Alatospora acuminata*
Spores not as above .. .. (17)
(17) Spore consisting of a main axis somewhat swollen at the base bearing a whorl of three branches at the widest part .. .. *Triscelophorus monosporus*
Spore not as above .. .. (18)
(18) Arms of spore with parallel sides .. .. .. *Lemonniera aquatica*
Arms of spore with sides converging towards the free ends .. .. *Lemonniera brachycladia*

ACKNOWLEDGMENTS

I wish to thank all those members of the Botany Department, Rhodes University, who assisted with the collection of material, especially Professor E. S. Twyman for his advice and encouragement; Professor C. T. Ingold for confirming that the two new species are, to his knowledge, as yet, undescribed; Mr. A. Milne for his assistance with the Latin diagnoses; and the Council for Scientific and Industrial Research for a bursary which I have received from them.

REFERENCES

DIXON, P. A., 1959. "Stream Spora in Ghana." *Trans. Brit. Mycol. Soc.* 42 (2), 174–176.

HUDSON, H. J. and INGOLD, C. T., 1960. "Aquatic hyphomycetes from Jamaica." *Trans. Brit. Mycol. Soc.* 43 (3), 469–478.

INGOLD, C. T., 1942. "Aquatic Hyphomycetes of Decaying Alder Leaves." *Trans. Brit. Mycol. Soc.* 25 (4), 339–417.

——— 1943. "*Triscelophorus monosporus* n. Gen. n. sp., An Aquatic Hyphomycete." *Trans. Brit. Mycol. Soc.* 26 (3 and 4), 148–152.

——— 1949. "Aquatic Hyphomycetes from Switzerland." *Trans. Brit. Mycol. Soc.* 32 (3 and 4), 341–345.

——— 1956. "Stream Spora in Nigeria." *Trans. Brit. Mycol. Soc.* 39 (1), 108–110.

——— 1958. (*a*) "Aquatic Hyphomycetes from Uganda and Rhodesia." *Trans. Brit. Mycol. Soc.* 41 (1), 109–114.

——— 1958. (*b*) "New Aquatic Hyphomycetes: *Lemonniera brachycladia, Anguillospora crassa* and *Fluminispora ovalis.*" *Trans. Brit. Mycol. Soc.* 41 (3), 365–372.

——— 1959. "Aquatic Spora of Omo Forest, Nigeria." *Trans. Brit. Mycol, Soc.* 42 (4), 479–485.

RANZONI, F. V., 1953. "Aquatic Hyphomycetes of California." *Farlowia* 4, 353–398.

Since submitting the paper for publication the attention of the author has been drawn to records of some of these Hyphomycetes from Sweden:

NILSSON, S., 1958. "On Some Swedish Freshwater Hyphomycetes". *Svensk. Bot. Tidskr.* 52, 291–318.

WILLEN, T., 1958. "Conidia of Aquatic Hyphomycetes amongst Plankton Algae." *Bot. Not.* 111, 431–435.

and from Japan:

TUBAKI, K., 1957. "Studies on the Japanese Hyphomycetes (III) Aquatic Group. *Bull. Nat. Sci. Mus. Tokyo.* 41, 249–268.